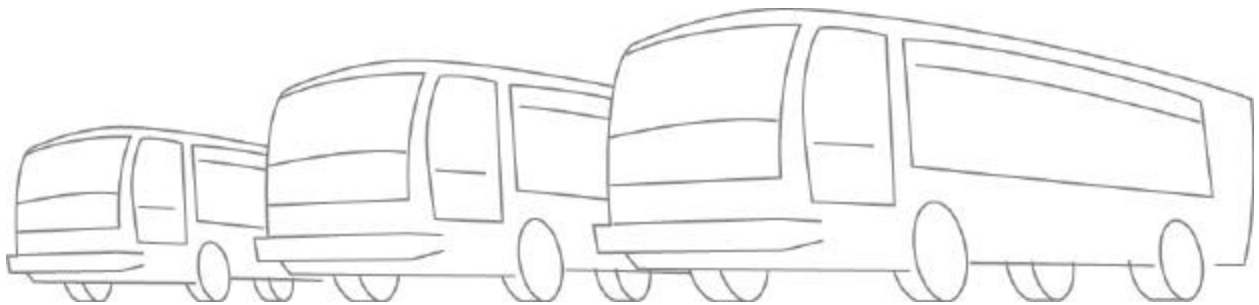


California Environmental Protection Agency



STATUS REPORT PUBLIC TRANSIT BUS FLEET RULE



March 2002

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
I. BACKGROUND	
A. Regulation Summary & Board Directions	4
B. September Public Meeting & Board Directions	7
II. OUTREACH TO TRANSIT AGENCIES	8
III. IMPLEMENTATION PROGRESS	
A. Fuel Path Selection.....	10
B. NOx Emission Average Update	12
C. Alternative NOx Strategy Update	13
D. Transit Agency Activities Beyond the Requirements.....	16
IV. OTHER ISSUES	
A. PM Emission Control	16
B. Hybrid-Electric Bus	17
C. Other Resolution Directives	18
REFERENCES	19

TABLES

Table 1: Comparison of Fuel Path Requirements.....	5
Table 2: Reported Transit Agencies' NOx Fleet Averages.....	12
Table 3: Transit Agencies with Approved Alternative NOx Strategy Plans	14
Table 4: Withdrawn or Incomplete Alternative NOx Strategy Applications	15

FIGURES

Figure 1: Two- and Four-Stroke Engines (2001)	11
Figure 2: Two- and Four-Stroke Engines (2002)	11

APPENDICES

Appendix A: Board Resolution 01-31	
Appendix B: Fuel Path Selection and Bus Fleet Total (2001)	
Appendix C: Transit Agencies by Fuel Path and Fleet Size	
Appendix D: Number of Diesel and Alternative Fuel Buses by Air District (2001)	
Appendix E: Fleet Composition by Fuel Type (2001-2002)	
Appendix F: Letter from Transit Agencies	
Appendix G: California Transit Association Presentation	
Appendix H: Estimated Timeframes for Diesel Emission Control Strategies Verification	

EXECUTIVE SUMMARY

Background

In February 2000, the Air Resources Board (ARB or Board) adopted the public transit bus fleet regulation (title 13, California Code of Regulations (CCR), sections 1956.1-1956.4, 1956.8 and 1965, as amended on February 24, 2001). This regulation is designed to achieve significant reductions in particulate matter (PM) and oxides of nitrogen (NOx) emissions through the implementation of a fleet rule and emission standards for new transit bus engines. Emission reductions are achieved through purchasing new low-emission buses or repowering older, higher-emitting buses to lower-emitting configurations. Reductions in diesel PM are also achieved through the retrofit of engines with emission control systems and the use of low sulfur fuel. Long-term emission reductions are achieved through establishing increasingly more stringent new engine standards. Over time, ultra-low, near-zero, and zero emissions buses will replace older higher emitting engines.

The Board, through discussion at the February 24, 2000, public hearing and Resolution 00-2 (February 24, 2000), directed staff to provide regular updates on the progress of implementation of the regulation. At the September 21, 2001, Board meeting, staff updated the Board regarding: (1) transit agencies' progress in implementing the regulations; (2) implementation of NOx emission reduction strategies as an alternative to purchasing buses with complying model year (MY) 2006 engines including an analysis of the first exemption application; (3) status of advanced aftertreatment systems; and (4) development of hybrid-electric bus test procedures. At the September meeting, the Board expressed concern with the compliance progress of the transit agencies in meeting the NOx fleet average and the low participation of the transit agencies in the alternative NOx strategy exemption. At the conclusion of the meeting, the Board asked staff to report back in six months on the transit agencies' progress in complying with the 4.8 grams per brake horsepower-hour (g/bhp-hr) NOx fleet average and on the implementation progress of the alternative NOx strategy exemption applications.

NOx Emission Average Update

As of the September meeting, 14 transit agencies had not demonstrated that they would meet the 4.8 g/bhp-hr NOx fleet average as of October 1, 2002. The reasons for the fleet average exceedances include using incorrect NOx emission values in the calculations and calculating the fleet average using NOx emission values of buses that do not meet the definition of an urban bus. Since that time, a number of transit agencies have revised their planned bus fleet purchases and retirements and indicate they will comply with the fleet average by October 2002.

As of February 2002, five transit agencies still project they will exceed the required NOx fleet average. Of the five transit agencies, Arcata/Mad River Transit System and Santa Rosa CityBus stated they will be in compliance by November 2002 and December 2002, respectively, because of their bus delivery schedules. San Luis Obispo Regional Transit and South County Transit have told staff that they will be in compliance by December 2003 because budgetary constraints prevent them from purchasing new buses or engines in the timeframe necessary to comply. The fifth, Fairfield/Suisun

Transit, will not be able to complete their repowering and diesel-to-alternative-fuel engine conversion projects until the end of 2002.

Staff is very concerned that these five transit agencies have not demonstrated that they will comply by October 1, 2002 with the NOx fleet average. While the reporting violation is a procedural violation only, staff views the potential violation of the NOx fleet average much more seriously and will therefore issue notices of violation to any transit agency that is not in compliance by October 1, 2002. However, staff is sensitive to the difficulties faced by smaller rural transit agencies in meeting the requirements and will take this into consideration when determining penalties.

Alternative NOx Strategy Update

The new engine emission standards applicable to manufacturers are set forth in title 13, CCR, section 1956.1. The regulation prohibits engine manufacturers from selling new transit bus engines during MY 2004 through 2006 that exceed a NOx emission standard of 0.5 g/bhp-hr. However, the Board also adopted an alternative NOx strategy (title 13, CCR, sections 1956.2 (c)(8) and (d)(7)) that allows transit agencies to apply, by June 30, 2001, for an exemption that would allow the purchase of buses with engines that do not meet the 2004-2006 MY engine emission standards if specified criteria are met. Transit agencies that are approved for the exemption may purchase buses with diesel engines with NOx certified levels higher than 0.5 g/bhp-hr. The exemption is the only mechanism allowed by the regulation for transit agencies to purchase diesel buses with non-complying engines during those three years. Alternatively, there is no requirement that transit agencies must purchase buses during 2004-2006, so a transit agency could comply by not purchasing any diesel buses.

Of the 15 transit agencies that applied for the exemption by June 30, 2001, seven transit agencies subsequently received approval for their emission reduction plans and are eligible for the exemption. The remaining have either formally withdrawn in writing or failed to submit an approvable NOx reduction plan by December 31. Those that have failed to submit an approvable plan will not be able to purchase new buses during 2004-2006. These requirements were described in Resolution 01-31 (September 20, 2001).

All seven transit agencies with approved emission reduction plans have made written commitments to ARB to fund and conduct a joint demonstration of advanced NOx aftertreatment technology. Provided the demonstration is initiated by December 31, 2002, as stipulated in Resolution 01-31 (September 20, 2001), these transit agencies may purchase new transit bus engines during 2004-2006 that do not meet the 0.5 g/bhp-hr NOx standard. Two transit agencies that have not applied for the alternative NOx strategy exemption have also committed to participating in the joint demonstration, and another transit agency has informed staff that it is planning a separate NOx demonstration.

PM Emission Control

Along with reducing the NOx fleet averages, transit agencies are required to reduce PM emissions by a minimum of 85 percent through retrofitting their bus engines with

advanced aftertreatment technology. Staff has established a program to verify these aftertreatment devices, and as of February 2002, two devices applicable to MY 1994-2001 four-stroke engines have been verified. Currently there are no retrofit devices verified for engines older than 1994 MY, and no devices are verified for any two-stroke engine. The regulation requires transit agencies to retrofit 100 percent of their pre-1991 MY diesel engines, and differing percentages of their 1991 to 1995 MY diesel engines, depending on their fuel path, by January 1, 2003. Staff believes that the technology will not be available for pre-1994 MY engines in time to meet the January 2003, regulatory deadline.

Staff recommends that the regulation be revised to allow transit agencies to retrofit newer bus engines provided the same number of retrofits are completed by January 1, 2003, as would be required by the current regulation. This would be accomplished using the funds already earmarked by the transit agencies for the retrofit of the older engines. Staff plans to propose a revised implementation schedule for the Board's consideration in September 2002. If the Board approves this recommendation, staff will work with the transit agencies in the interim to begin the process towards retrofitting all the required engines.

I. BACKGROUND

In February 2000, the Air Resources Board (ARB or Board) adopted the public transit bus fleet regulation (title 13, California Code of Regulations (CCR), sections 1956.1-1956.4, 1956.8 and 1965, as amended on February 24, 2001). This regulation was designed to achieve significant reductions in particulate matter (PM) and oxides of nitrogen (NOx) emissions, through the implementation of a fleet rule and new bus engine emission standards whereby transit agencies would purchase cleaner buses and install emission control equipment to existing engines.

A. Regulation Summary & Board Directions (February 2000)

The public transit bus regulation achieves near-term emission reductions by requiring transit agencies to purchase new low-emission buses and retrofit or repower older, higher-emitting urban bus engines to lower-emitting configurations. Long-term emissions benefits are achieved through establishing increasingly more stringent new engine standards. Consequently, new bus engines with ultra-low, near-zero, and zero-emissions will replace the older higher emitting engines over time. Reporting requirements ensure compliance and progress in achieving the required reductions.

An urban bus is defined as a heavy heavy-duty diesel-powered¹ passenger-carrying vehicle with a load capacity of fifteen or more passengers intended primarily for intra-city operation, i.e., within the confines of a city or greater metropolitan area (title 13, CCR, section 1956.2). Typical features of urban buses include quick-opening exit and entrance doors and fare collection equipment. It must be noted that diesel hybrid-electric buses are considered to be urban buses although they are usually not powered by heavy heavy-duty engines.

The regulation does not apply to buses used in shuttle services, airport shuttle services, paratransit services, school transportation services and charter services unless urban buses are used to provide those services. The regulation also does not apply to military buses. Buses used to provide long-distance service, that are generally equipped with luggage compartments, rest rooms, and overhead storage, are also not included.

There are two major components to the regulation: (1) a transit bus fleet rule applicable to transit agencies; and (2) more stringent emission standards for new urban bus engines applicable to urban bus engine manufacturers. The transit bus fleet rule required fleet operators by January 31, 2001 to chose between operating a diesel bus fleet (the diesel path) or an alternative-fuel bus fleet (the alternative-fuel path). The rule contains different requirements for each path and is in effect from 2001 through 2015 (title 13, CCR, sections 1956.2). Table 1 shows the requirements for the two fuel paths.

¹ A diesel-powered urban bus refers to a bus powered by a diesel-cycle engine, which by definition in the regulation includes alternative-fuel engines such as natural gas, propane, and methanol.

TABLE 1: Comparison of Fuel Path Requirements

Year	Diesel Path	Alternative-Fuel Path
July 2002	Require use of low sulfur fuel (15 ppm)	Require use of low sulfur fuel (15 ppm)
October 2002	4.8 g/bhp-hr NOx fleet average	4.8 g/bhp-hr NOx fleet average
January 2003 to January 2009	PM Retrofit Requirements	
	Tier 1 (pre-1991) 100% by January 1, 2003	Tier 1 (pre-1991) 100% by January 1, 2003
	Tier 2 (1991-1995) 50% by 1/1/03 100% by 1/1/04	Tier 2 (1991-1995) 20% by 1/1/03 75% by 1/1/04 100% by 1/1/05
	Tier 3 (1996- pre-Oct. 2002) 20% by 1/1/05 75% by 1/1/06 100% by 1/1/07	Tier 3 (1996-pre-Oct. 2002) 20% by 1/1/07 75% by 1/1/08 100% by 1/1/09
July 2003	3 bus demo of ZEBs for large fleets (>200)	Not applicable
January 2008	15% of new buses are ZEBs for large fleets (>200)	Not applicable
January 2010	Not applicable	15% of new buses are ZEBs for large fleets (>200)

For both paths, reductions from the older in-use fleet are achieved through a minimum NOx fleet average emission requirement achieved partly by purchasing cleaner diesel or alternative-fuel buses, and through requirements for retrofits to control diesel PM. The alternative-fuel path achieves equivalent NOx reductions and greater PM reductions through 2015 than the diesel path due to inherently low in-use PM emissions from alternative-fuel buses (ARB 1999b). Currently, PM emissions from alternative-fuel buses are on the order of 20 to 100 times lower than diesel buses. In the future, diesel buses will be equipped with emission control systems which will reduce the PM down to levels comparable to those of alternative-fuel buses.

The fleet rule also requires larger fleets on the diesel path to undertake a zero-emission bus demonstration project by July 1, 2003. If the project is judged to be successful by the ARB in 2006, larger fleets on both paths will be required to purchase zero-emission buses equal to 15 percent of the total bus purchases. This requirement takes effect in 2008 for those on the diesel path and 2010 for those on the alternative-fuel path.

The current NOx emission standard for diesel urban bus engines is 4.0 grams per brake horsepower-hr (g/bhp-hr). Manufacturers of alternative fuel engines can also certify their engines to an optional NOx emission standard between 0.5 g/bhp-hr and 2.5 g/bhp-hr (by 0.5 g/bhp-hr increments). Beginning with October 1, 2004, new diesel urban bus engines are required to certify to a NOx standard of 0.5 g/bhp-hr; beginning

with model year (MY) 2007, the NO_x certification standard declines to 0.2 g/bhp-hr for all forms of bus engines. The rule provides an alternative approach to meeting this more stringent 2004-2006 NO_x standard which allows transit agencies to purchase higher emitting buses provided they demonstrate and achieve greater overall NO_x emission benefits through 2015.

The PM standard for diesel urban bus engines is currently 0.05 g/bhp-hr. The PM standard declines to 0.01 g/bhp-hr for new engines as of October 1, 2002. This standard can be met by using PM aftertreatment systems such as diesel particulate filters.

Low-sulfur diesel fuel is necessary for most aftertreatment technologies to function efficiently and reliably for diesel engines. With higher sulfur fuel, trap plugging and catalyst fouling can occur. Therefore, the transit fleet rule requires transit agencies using diesel fuel, regardless of fuel path, to purchase and use diesel fuel with a sulfur limit of 15 parts per million (ppm) beginning July 1, 2002, in order to be consistent with the PM retrofit requirements. Transit agencies that operate in federal ozone attainment areas and have fewer than 20 buses in their active fleets, however, would not be subject to this requirement until July 1, 2006. Because federal ozone attainment areas tend to be outlying rural areas that may experience difficulty in securing delivery of low sulfur diesel fuel before full statewide implementation of the low-sulfur requirements in 2006, these fleets will also be allowed a delay in the PM retrofit requirements until January 1, 2007.

The ARB expects that the transit bus regulation will reduce NO_x emissions statewide by about seven tons per day (tpd) in 2020 (ARB 1999b). Furthermore, the regulation will reduce PM emissions from urban buses by requiring new buses to meet more stringent PM standards and by requiring retrofits to reduce PM from the existing diesel urban bus fleet. The estimated PM reduction in 2005, as a result of the PM retrofit requirements, is 300 pounds per day statewide. By 2020, the benefit from PM retrofits drops to 67 pounds per day due to the replacement of older dirtier engines with cleaner ones.

The following points summarize the regulation:

- A public transit fleet rule with two paths for compliance – a diesel path and an alternative-fuel path (see Table 1).
- A transit agency must have selected its fuel path by January 31, 2001.
- A 4.8 g/bhp-hr NO_x fleet average requirement for transit agencies as of October 1, 2002.
- PM retrofit requirements apply on January 1, 2003 for pre-1991 MY engines. All other pre-October 2002 urban bus engines must be retrofitted following a phase-in schedule that depends on model year and fuel path.

- Zero-emission bus (ZEB) demonstration project requirements in 2003 for large transit agencies on the diesel path.
- ZEB purchase requirements beginning in 2007 for large transit agencies on the diesel path and in 2009 for large transit agencies on the alternative-fuel path.
- Requirements for transit agencies to use low-sulfur fuel (15 ppm or less) in all their diesel vehicles beginning July 1, 2002.
- Reporting requirements as a mechanism to determine a transit agency's compliance with the public transit fleet rule.
- More stringent emission standards for diesel and dual-fuel urban bus engines, including a 0.01 g/bhp-hr PM standard starting in October 1, 2002 and a 0.5 g/bhp-hr NOx standard for MY 2004-2006.
- More stringent emission standards, including a 0.2 g/bhp-hr NOx standard and a 0.01 g/bhp-hr PM standard, for all 2007 and subsequent model year engines.
- An alternative NOx strategy exemption with the following requirements:
 - (1) each transit agency that needs an exemption must apply by June 30, 2001.
 - (2) the transit agency must demonstrate to the Executive Officer that it will achieve NOx emissions benefits through 2015 greater than would have been achieved through compliance with the engine standard.
 - (3) before granting the exemption, the Executive Officer must make a finding that transit agencies, after consultation with the EMA, are demonstrating, or have contracted to demonstrate, advanced NOx aftertreatment technology.

At the conclusion of the February 2000 adoption Hearing, the Board approved the regulation and directed staff to provide regular updates on the implementation of the regulation. Specifically, directives to staff were (1) to report back regularly on transit agency progress in implementing regulations; (2) to report back to the Board on implementation of NOx emission reduction strategies as an alternative to compliance with the 2004 requirements and to analyze the first exemption application and present its recommendation before the Board as part of the first update; (3) to report on the status of advanced aftertreatment systems; and (4) to report on progress on the development of hybrid-electric bus test procedures.

B. September 2001 Public Meeting & Board Directions

The ARB staff presented the first update to the Board on September 21, 2001. During the meeting, the Board members expressed a keen interest in the compliance progress of the transit agencies with regard to the 4.8 g/bhp-hr NOx fleet average and in the implementation progress of the alternative NOx strategy. As a result of the Board's discussions, staff was directed to implement the following tasks and to return in March 2002 (Appendix A) and report on the following items:

- 1) To work with transit agencies that have reported that they are unable to meet the required NOx fleet average of 4.8 g/bhp-hr by October 1, 2002, to assist them in achieving compliance, and to proceed with enforcement actions against those transit agencies that do not comply by October 1, 2002;
- 2) To make the necessary regulatory changes to allow transit agencies that applied for an exemption by June 30, 2001, additional time to demonstrate advanced NOx aftertreatment technology; to require transit agencies to commit resources to a demonstration project as of December 31, 2001; and to require those transit agencies to have initiated advanced NOx aftertreatment demonstrations by December 31, 2002; if the deadlines were not met, the Executive Officer was directed to rescind any conditional approvals granted previously;
- 3) To convene a delegation to meet with representatives of the Engine Manufacturers Association to assess and encourage efforts to advance the status of NOx emission control technology;
- 4) To continue development of a test procedure for the evaluation of hybrid electric bus emissions and to report back to the Board by late-2002 on progress in this effort;
- 5) To assist rural and smaller transit agencies in identifying, assessing, and implementing economies of scale and other strategies in infrastructure development to support alternative-fuel bus fleets; and
- 6) To be prepared to introduce a proposal to eliminate the diesel path option in the transit bus fleet rule if efforts towards clean diesel technology and compliance with low NOx emission standards do not improve considerably in the next six months.

II. Outreach to Transit Agencies (post-September 2001)

As noted above, the Board directed staff to work with engine manufacturers and transit agencies to encourage efforts to advance the status of advanced NOx control technology and improve compliance with the transit bus regulation. Since the September meeting, staff has communicated frequently with transit operators through meetings, phone conversations, e-mails, and written letters. The public transit bus website (www.arb.ca.gov/msprog/bus/bus.htm) has been redesigned to allow easier access to the relevant transit bus information and updated frequently with new information. Communications that needed to be sent to all transit agencies have been mailed, e-mailed, and posted to the public transit bus website. The following information summarizes major meetings held with transit agencies and engine manufacturers since September 2001.

Transit agencies that had applied for the alternative NOx strategy exemption were invited to a meeting in El Monte on October 17, 2001, to discuss the remaining implementation issues related to the alternative NOx strategy. The points discussed included: (1) the December 31, 2001, deadline for submission of a complete plan to demonstrate greater NOx emission benefits through 2015; (2) the December 31, 2001,

deadline for submission of a commitment of resources for the demonstration of advanced NOx aftertreatment technology; and (3) the December 31, 2002 deadline for the initiation of the NOx demonstrations.

On October 30, staff held a teleconference with the representatives of the Engine Manufacturers Association (EMA), the Manufacturers of Emission Controls Association (MECA), and the transit agencies that had applied for the alternative NOx strategy. The cost and availability of NOx aftertreatment devices for the demonstration were discussed. A representative from Kleen Air Systems gave an estimate for a selective catalytic reduction (SCR) system they produce.

On November 8, 2001, staff made a presentation before transit agencies at the California Transit Association (Cal Transit) Fall Conference in San Jose. Staff summarized actions required of transit agencies in 2002 and answered questions about compliance with the regulation. Following the conference session, staff attended a transit agency meeting on the NOx demonstration. Also in November, representatives of Cal Transit met with ARB Chairman Alan Lloyd and the Executive Office to discuss efforts many transit properties are making to meet and exceed requirements of the regulation.

Additional meetings that focused on the protocol proposed by staff for the advanced NOx aftertreatment demonstration were held on December 14, 18, and 19. Staff continued to provide guidance and support to transit agencies through phone calls, e-mails, and letters, thereby resulting in six transit agencies completing the application process required by December 31, 2001. Staff met again with transit agencies regarding the advanced NOx aftertreatment demonstration on January 22, 2002.

In addition to these meetings with transit agencies, a delegation of the Board consisting of Chairman Alan Lloyd and Mr. Matthew McKinnon, along with the Executive Officer and Deputy Executive Officer, met with representatives of the EMA on November 7, 2001. The purpose of this meeting was to assess and encourage efforts to advance the status of advanced NOx emission control technology. The EMA's representatives reiterated their position that, while the engine manufacturers had made no commitment to a NOx aftertreatment demonstration in transit buses, they would cooperate with transit agencies and ARB on furthering the demonstration. They also restated their position that the 2007 standard for transit bus engines is infeasible and must be harmonized with the nationwide 2007 standard for heavy-duty diesel engines or no complying transit bus engines will be available in California in 2007.

Finally, staff met once with representatives of the environmental organizations Union of Concerned Scientists, Coalition for Clean Air, and American Lung Association on November 6, 2001, and spoke with representatives by phone on other occasions. The purpose of this meeting was to answer questions by the environmentalists on the progress of rule implementation. As a follow-up of the meeting, staff gave the Coalition for Clean Air a list of transit agencies that were not yet in compliance with the NOx fleet average as of that date.

Staff also personally contacted each transit agency that was not in compliance with the NOx fleet average as of the September Board meeting. Through telephone calls and e-mail, staff worked with each transit agency to obtain letters detailing how and when each would be in compliance.

To summarize, outreach by staff to transit agencies since the September 20, 2001, Board meeting has been intensive and focused on achieving reductions in NOx emissions, as required by the transit bus regulation. Over 200 phone calls and e-mails, along with eight meetings, have taken place during the last quarter of 2001 alone. The results of this work are the subject of this staff report.

III. IMPLEMENTATION PROGRESS

The reporting requirements of the public transit bus fleet rule are set forth in title 13, CCR, section 1956.4. A summary of the data provided in the September 2001 transit bus status report will be provided in this chapter. Please note that some data have been revised since the September publication.

A. Fuel Path Selection (title 13, CCR, section 1956.2(c))

As stated in the September 2001 public transit bus fleet rule status report, 44 of the 71 transit agencies in California have selected the diesel path (Appendix B). A complete list of all the transit agencies with their fuel path selections is found in Appendix C. This list also shows the fleet size of the transit agencies for the years 2001 and 2002. Appendix D shows the number of buses categorized by fuel type in each air district as of January 1, 2001. The diesel buses operating in the Bay Area Air Quality Management District and the South Coast Air Quality Management District (SCAQMD) make up 82 percent of all diesel buses in California. In contrast, SCAQMD has the majority of the alternative fueled buses operating in California. Based on their submissions, transit agencies will increase the number of alternate fuel buses in their fleets by the year 2002 (Appendix E). Despite the decreasing number of diesel-fueled buses from year 2001 to 2002, diesel buses still outnumber alternative fuel buses by greater than two to one. Nevertheless, the public transit bus fleet regulation appears to be causing a gradual shift from diesel fuel to alternative fuels, even as the transit bus population increases.

Transit agencies are required to begin retrofitting diesel bus engines to reduce diesel PM by January 1, 2003. The PM retrofit schedule is divided into three tiers based on bus engine model year. As shown in Figures 1 and 2, a large number of buses with two-stroke engines fall within Tier 1 and 2 (pre-1991 and 1991-1995, respectively). In contrast, an overwhelming majority of the post-1995 engines (Tier 3) are four-stroke engines. As will be discussed later, there are technological challenges associated with retrofitting two-stroke and older engines; thus, it is useful to categorize engines into the retrofit tiers by age and whether they are two- or four-stroke.

FIGURE 1: Two- and Four-Stroke Engines (2001)

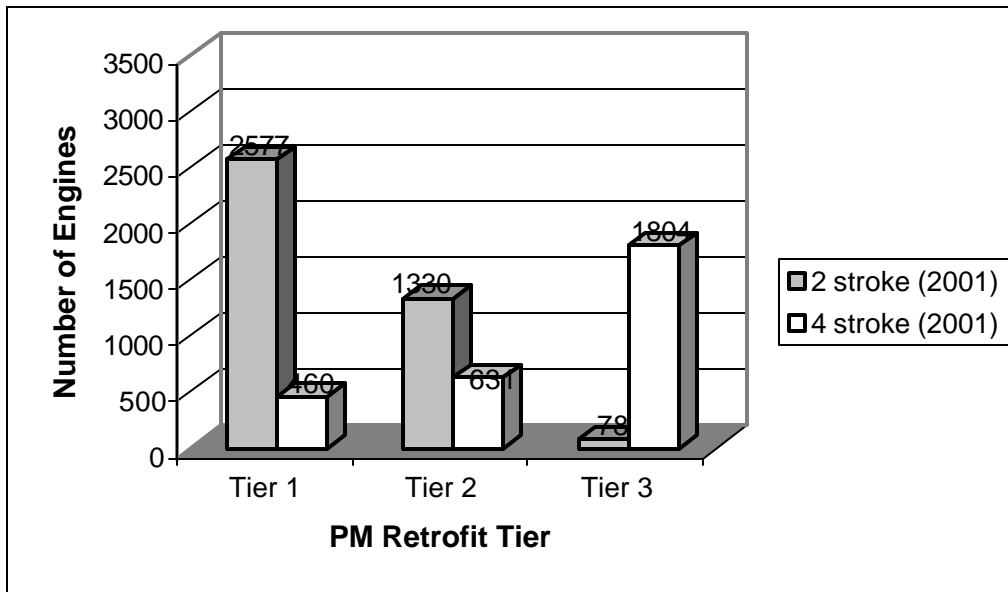
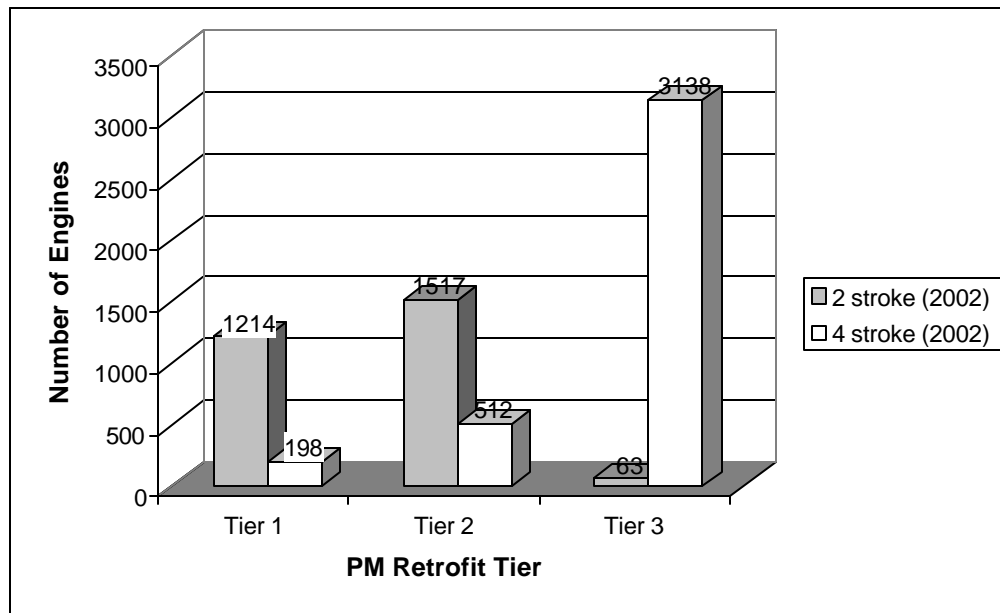


FIGURE 2: Two- and Four-Stroke Engines (2002)



B. NOx Emission Average Update (title 13, CCR, section 1956.2(e))

The regulation required transit agencies to submit their NOx fleet averages, based on engine certification values, as of January 1, 2001. If the NOx fleet average was higher than 4.8 g/bhp-hr, transit agencies were required to submit a report by January 31, 2001, detailing actions planned to achieve that average by October 1, 2002.

As of the September 2001 Board meeting, 14 transit agencies had supplied insufficient information or miscalculated their NOx fleet averages. Prior to and following the September 2001 meeting, staff notified these agencies, both by phone and in writing, of the insufficiencies or miscalculations and requested revised bus fleet information. Staff has worked with these 14 transit operators to help resolve implementation issues.

Currently, of the 71 transit agencies, five transit agencies project they will exceed the October 1, 2002 required NOx fleet average (Table 2). Four of these five are very small transit agencies, with 25 or fewer urban transit buses in their fleets. Arcata/Mad River Transit System and Santa Rosa CityBus have stated they will be late in compliance because of their bus delivery schedules. San Luis Obispo Regional Transit and South County Transit have budgetary constraints that will prevent them from purchasing new buses or engines in the timeframe necessary to comply. The fifth, Fairfield/Suisun Transit, will not be able to complete their repowering and diesel-to-alternative-fuel engine conversion projects until the end of 2002.

Staff is very concerned that these five transit agencies have not demonstrated that they will comply by October 1, 2002 with the NOx fleet average. While the reporting violation is a procedural violation only, staff views the potential violation of the NOx fleet average much more seriously and will therefore issue notices of violation to any transit agency that is not in compliance by October 1, 2002. However, staff is sensitive to the difficulties faced by smaller rural transit agencies in meeting the requirements and will take this into consideration when determining penalties.

Table 2: Reported Transit Agencies' NOx Fleet Averages (as of October 1, 2002)

Transit Agency	Reported NOx Fleet Average	Fleet Size	Projected Compliance Date
Arcata/Mad River Transit System	5.63	4	November 2002
Fairfield/Suisun Transit	6.24	40	December 2002
San Luis Obispo Regional Transit Authority	5.83	18	December 2003
Santa Rosa CityBus	5.12	25	December 2002
South County Area Transit	8.13	4	December 2003

**C. Alternative NOx Strategy Update
(title 13, CCR, sections 1956.2(c)(8) and (d)(7))**

1. Background

The new engine standards applicable to manufacturers are set forth in title 13, CCR, section 1956.1. The regulation prohibits engine manufacturers from selling transit bus engines during MY 2004 through 2006 that exceed a NOx emission standard of 0.5 g/bhp-hr. The two major bus engine manufacturers have indicated they will not be providing engines that meet the 0.5 g/bhp-hr NOx emission standard. However, the alternative NOx strategy set forth in title 13, CCR, sections 1956.2 (c)(8) and (d)(7) allows transit agencies to apply, by June 30, 2001, for an exemption that would allow the purchase of buses with engines that do not meet the 2004-2006 MY engine emission standards if specified criteria are met. Transit agencies that are exempted may purchase buses with diesel engines with NOx certified levels higher than 0.5 g/bhp-hr. The exemption is the only mechanism allowed by the regulation for transit agencies to purchase diesel buses with non-complying engines during those three years. Alternatively, there is no requirement that transit agencies must purchase buses during 2004-2006, so a transit agency could comply by not purchasing any diesel buses.

The rule has three parts. First, each transit agency that needs an exemption must have applied by June 30, 2001 (title 13, CCR, sections 1956.2(c)(8)(A) and (d)(7)(A)). Transit agencies that did apply will not be able to purchase new diesel engines during the three-year time period unless the engine meets the NOx and PM standards.

Second, the transit agency must have demonstrated to the Executive Officer that it will achieve NOx emissions benefits through 2015 greater than would have been achieved through compliance with the engine standards (title 13, CCR, sections 1956.2 (c)(8)(B) and (d)(7)(B)). Transit agencies can modernize their fleets through scrapping older engines and repowering with newer engines. Retirement of the oldest buses in their fleets is another method to achieve compliance.

Finally, before granting the exemption, the Executive Officer must make a finding that transit agencies, after consultation with the EMA, are demonstrating, or have contracted to demonstrate, advanced NOx aftertreatment technology (title 13, CCR, sections 1956.2 (c)(8)(C) and (d)(7)(C)).

During the September 2001 Board meeting, staff was given the following directives relating to the alternative NOx strategy (Resolution 01-31):

- 1) To make the necessary regulatory changes to allow transit agencies that applied for an exemption by June 30, 2001, additional time to demonstrate advanced NOx aftertreatment technology; to require transit agencies to commit resources to a demonstration project as of December 31, 2001; and to require those transit agencies to have initiated advanced NOx aftertreatment demonstrations by December 31, 2002. If these deadlines were not met, the Executive Officer shall rescind any conditional approvals granted previously; and

- 2) To convene a delegation to meet with representatives of the Engine Manufacturers Association to assess and encourage efforts to advance the status of NOx emission control technology.

2. Exemption Applications

Of the 15 transit agencies that originally applied as of June 30, 2001, only seven transit agencies received approval for their plans and are eligible for the exemption (Table 3). The remaining have either formally withdrawn in writing or failed to submit at least one approvable NOx reduction plan by December 31, 2001. Those that have failed to submit an approvable plan will not be able to purchase new, non-complying diesel bus engines during 2004-2006.

TABLE 3: Transit Agencies with Approved Alternative NOx Strategy Plans

AQMD: Air Quality Management District
APCD: Air Pollution Control District

Agency	Fuel Path	Air District
Alameda/Contra Costa Transit District	D	Bay Area AQMD
Eastern Contra Costa Transit Authority	D	Bay Area AQMD
Golden Gate Bridge Highway and Transportation District	D	Bay Area AQMD
Santa Clara Valley Transportation Authority	D	Bay Area AQMD
El Dorado County Transit Authority	D	El Dorado County APCD
Merced County Transit	D	San Joaquin Valley APCD
Visalia City Coach	D	San Joaquin Valley APCD

The transit agencies that withdrew or did not complete their applications include Central Contra Costa Transit Authority, Livermore/Amador Valley Transit Authority, San Francisco Municipal Railway, Monterey-Salinas Transit, Long Beach Transit, City of Norwalk, San Joaquin Regional Transit, and Montebello Bus Lines (Table 4). Transit agencies that have withdrawn their applications indicated to staff that they have revised their bus purchase plans to include no diesel bus purchases between 2004-2006.

TABLE 4: Withdrawn or Incomplete Alternative NOx Strategy Applications

Agency	Fuel Path	Air District
Central Contra Costa Transit Authority	D	Bay Area AQMD
Livermore/Amador Valley Transit Authority	D	Bay Area AQMD
San Francisco Municipal Railway	D	Bay Area AQMD
Monterey-Salinas Transit	D	Monterey Bay Unified APCD
San Joaquin Regional Transit	D	San Joaquin Valley APCD
Long Beach Transit	D	South Coast AQMD
Montebello Bus Lines	D	South Coast AQMD
City of Norwalk	D	South Coast AQMD

3. NOx Aftertreatment Demonstration Status

Another requirement of the alternative NOx reduction strategy application is the initiation of an advanced NOx aftertreatment demonstration by December 31, 2002. As stipulated by the Board at the September 2001 public meeting (Resolution 01-31, September 20, 2001), each transit agency that applied for an exemption has the option of performing a joint or individual demonstration. The guidelines for a joint demonstration are as follows: (1) may involve several or all transit agencies that applied for an exemption; (2) must include at least three buses operating in fare service; and (3) must demonstrate NOx aftertreatment technology that will offer commercial potential (i.e., reduce NOx emissions by 70 percent or more). If an individual demonstration is performed, then the transit agency is required to include at least one bus operating in fare service.

During the various meetings since the September Board meeting, transit operators and staff have worked with emission control equipment manufacturers on planning a joint advanced NOx aftertreatment demonstration. All seven transit agencies that must participate have committed to do a joint demonstration project. In addition to the seven transit agencies, San Mateo County Transit District and Central Contra Costa Transit Authority have also committed to participating in the joint NOx demonstration (Appendix F). Torrance Transit has told staff they plan to do a separate NOx demonstration.

Thus far, the most promising advanced NOx aftertreatment technology for the demonstration project appears to be selective catalytic reduction. Selective catalytic reduction (SCR) uses a reductant, usually urea or ammonia, to convert NOx to

harmless gases. The reducing agent is injected into the exhaust upstream of a catalyst bed. As the exhaust gases and the reductant pass over a catalyst applied to either a ceramic or metallic substrate, NO_x emissions can be reduced to gaseous nitrogen and water vapor. Several studies in heavy-duty engines have estimated that SCR efficiencies can range from 50-80 percent or even higher (Tim Johnson, personal communication, 2001). In addition to reducing emissions of NO_x, SCR simultaneously reduces emissions of HC by 50 to 90 percent and PM by 30 to 50 percent (MECA 2000a). In general, higher efficiencies, however, have been reported on steady-state cycles. Attaining high efficiencies from mobile engines operating on transient duty cycles is more challenging.

D. Transit Agency Activities Beyond the Requirements

Several of the transit agencies have informed staff that they are moving to reduce emissions from their fleets more aggressively than required by the transit bus fleet rule. Those transit agencies have submitted a letter detailing those activities (Appendix F). To summarize, they are: (1) aggressively repowering their older two-cycle engines; (2) switching to low sulfur (<15 ppm) diesel fuel earlier than the required July 1, 2002, date; (3) installing particulate filters earlier than required; and (4) testing various advanced technology engines and power systems that have lower NO_x and PM emissions than currently certified engines. The potential benefits of these changes are discussed in a presentation made by the California Transit Association (Appendix G). This presentation also detailed the specific transit agencies that are incorporating these changes.

IV. OTHER ISSUES

Beyond the issues discussed in the previous chapters, there are still a few outstanding issues related to the transit bus regulation that must be addressed.

A. PM Emission Control

Title 13, CCR, section 1956.2 (f) requires that older engines be retrofitted to reduce diesel PM earlier than newer engines. Specifically, 100 percent of pre-1991 MY (Tier 1) diesel engines must be retrofitted with technology that will reduce diesel PM by 85 percent by January 1, 2003. The same requirement applies to a lower percentage of MY 1991 through 1995 (Tier 2) engines by January 1, 2003, under a phase-in period. The deadline for full compliance for all 1995 and older models is January 1, 2004, for transit agencies on the diesel path and January 1, 2005, for transit agencies on the alternative-fuel path. Included in the retrofit requirements are the following exemptions:

- (1) MY 1990 and earlier engines that were originally certified to 0.6 g/bhp-hr PM and have been retrofitted to 0.1 g/bhp-hr PM with an ARB certified retrofit device are exempt from further retrofits;
- (2) Tier 2 and 3 buses, operated by transit agencies on the alternative fuel path, that are within two years of retirement are exempt from the retrofit requirements; and

- (3) Tier 2 and 3 buses, operated by transit agencies on the diesel path, that are within one year of retirement are exempt from the retrofit requirements.

Staff is currently evaluating reports submitted by transit agencies which detail retrofit plans for their diesel-fueled, dual-fueled, bi-fueled, or diesel hybrid buses. A summary of the analysis will be presented at the March Board meeting.

As of the publication of this report, two particulate control devices have been verified, and these have application only for 1994 and newer four-stroke engines. Both devices are passive diesel particulate filters that utilize exhaust gas heat and a catalyst to regenerate. In general, two-stroke bus engines are more technologically challenging to retrofit with a passive DPF because PM emissions tend to be higher than four-stroke engines. Furthermore, the exhaust gas temperature may not meet the minimum temperature required for spontaneous regeneration.

Appendix H provides the estimated timeframes for diesel emission control strategies verification for transit buses. These estimates are based primarily on information supplied by MECA. As noted above, Tier 1 two-stroke engines must be retrofitted by January 1, 2003, but the estimated verification timeframe for many pre-1991 two-stroke engines is sometime during 2003. Even if the estimates were accurate, the deadline for Tier 1 two-stroke engines would have passed by the time the verifications were to be performed.

Staff believes that the technology will not be available for pre-1994 MY engines in time to meet the January 2003, regulatory deadline. As a result, staff recommends the regulation be revised to allow transit agencies to retrofit newer bus engines provided the same number of retrofits are completed by January 1, 2003, as would be required by the current regulation. This would be accomplished using the funds already earmarked by the transit agencies for the retrofit of the Tier 1 and Tier 2 engines. Consequently, the retrofit implementation schedule in the regulation will require revision. Staff will present regulatory changes reflecting a revised implementation schedule for the Board's consideration in September 2002. If the Board approves this recommendation, staff will work with the transit agencies in the interim to begin the process towards retrofitting all the required engines.

B. Hybrid-Electric Bus

As discussed in the September 2001 Board meeting, ARB continues to work with hybrid-electric bus manufacturers, hybrid drive train developers (e.g., BAE Systems and Allison), and transit bus fleet managers to further understand the operating characteristics and maintenance concerns of transit buses, both conventional and hybrid designs. Staff is working closely with key industry officials to facilitate the development of durability requirements, such as emission deterioration factors, in-use compliance measures, and onboard diagnostics requirements. The ARB staff plans to propose heavy-duty hybrid-electric vehicle test procedures for the Board's consideration and adoption in September 2002.

C. Other Resolution Directives

The ARB staff was directed to assist rural and smaller transit agencies in identifying, assessing, and implementing economies of scale and other strategies in infrastructure development to support alternative-fuel bus fleets (Resolution 01-31, September 20, 2001). To date, staff has been unable to proceed with this directive due to limited resources. Staff will be meeting with small and/or rural transit agencies in April 2002 to begin accomplishing the goals set forth in the resolution.

The ARB staff was also asked to be prepared to introduce a proposal to eliminate the diesel path option in the transit bus fleet rule if efforts towards clean diesel technology and compliance with low NOx emission standards do not improve considerably in the next six months. Based on the information provided by the transit agencies, staff concludes that almost all the transit agencies are making good efforts towards meeting and exceeding the goals of the public transit bus fleet rule. Therefore, staff does not recommend a proposal to eliminate the diesel path option.

REFERENCES

ARB 1999b. The Public Transit Bus Fleet Rule: Initial Statement of Reasons, December 1999.

MECA 2000a. Manufacturers of Emissions Controls Association (MECA), Emission Control Retrofit of Diesel-Fueled Vehicles, March 2000.